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A paradigm shift in imaging for renal colic – Is it time to say good bye to an old trusted friend?

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ABSTRACT

Objectives: To study the changing pattern in the use of intravenous urogram (IVU) and non-contrast enhanced CT (CTKUB) for evaluation of flank pain at a single centre.**Methods:** All patients who underwent either an IVU or CTKUB at a single, tertiary care center from January 2002 to December 2007 were retrospectively identified from the radiology database. Study samples were divided into two groups: Pediatric (14 years or less) and Adult (greater than 14 years). For each group, overall trends as well as trends across referral setting and gender were explored by plotting line graphs using SPSS version 15.**Results:** During the study period a total of 11245 uro-radiological examinations were performed using either IVU (43.7%, $n = 4915$) or CTKUB (56.3%, $n = 6330$). A remarkable majority of procedures (95.5%, $n = 10741$) was performed in adult patients. Overall, the respective proportions of IVU and CTKUB were 87.9% ($n = 43$) and 12.1% ($n = 61$) in the pediatric group whereas 41.6% ($n = 4472$) and 58.4% ($n = 6269$) in adults. Majority in both groups were ambulatory patients (Pediatrics 83.7%, Adults 76.7%). During 2002–2007, the yearly proportion of CTKUB increased from 27% to 80% in adults and from 3% to 27% in children.**Conclusions:** There is major shift in the choice of imaging in adults from IVU to CTKUB during years 2002–2007. In pediatric patients, IVU referrals still comprise the greater proportion of uro-radiological exams.

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1. Introduction

Renal colic, with an estimated lifetime prevalence of 12%¹ is a common reason for presentation to the emergency department and urology clinics.^{2,3} Most of these cases are attributable to urinary calculus¹ which is a highly recurrent condition with the 10-year recurrence rate exceeding 35%.^{3,4}

Radiological imaging is crucial not only in diagnosis but also in making therapeutic decisions in patients with urolithiasis. The available options include plain radiograph KUB, IVU, CTKUB, US and the more sophisticated MR Urography.^{2,3} For decades, IVU has dominated the diagnostic algorithms for acute flank pain but, more recently, CTKUB has emerged as a tough competitor.^{3,5} Evidence in favor of CTKUB is growing by the day; complete replacement of IVU with CTKUB seems imminent.

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The choice of imaging modality should be based on its accuracy, safety, cost-effectiveness, availability, adaptability and ease of interpretation.^{3,6} Diagnostic yield, radiation dose and time-to-diagnosis remain constant across developed and developing countries as well as across public- and private-funded health care systems. However, the same cannot be presumed about availability and cost of the diagnostic services or of the required human resources. A clinician weighs all these aspects, and their overall clinical impact, before making a referral for either modality. Consequently, the diagnostic preferences may differ across diverse health care systems.

We analyzed the trends of referral for uro-radiological studies, over a period of six years, at a single tertiary care centre, in a developing country with a predominantly private-funded health care system. We hope that our findings will assist in pragmatic planning of the diagnostic facilities for these patients.

2. Methods

The study was conducted at a 600 bedded tertiary care University Hospital. The department of Radiology provides services

to hospitalized patients (HP) as well as those under care of the Emergency department (ED) of the hospital. In addition, ambulatory patients (AP) are referred from both hospital affiliated clinics and independent health care providers.

This is a retrospective cross sectional study in which all patients who underwent either CTKUB or an IVU examination from January 1, 2002 until December 31, 2007 were included. Only those patients who had CTKUB examination done with intravenous contrast examination were excluded. No other exclusion criteria present in our study. The referring decision was made by primary clinicians in all cases.

Records of all IVU and CTKUB performed during a given period were retrieved from the Radiology Information System. Both these procedures were performed, after informed consent, on patients with renal colic and a high suspicion for urolithiasis, upon discretion of the referring physician. The corresponding age (0–14 years = Pediatric; >14 years = Adult) and gender of patient as well as the practice location (ED, HP and ambulatory patients) and specialty (urology, surgery and allied and medicine and allied) of referring physician were documented for each exam.

Statistical Package for Social Sciences (version 15) was employed for data entry and analysis. The study sample was divided into two age groups viz. pediatric (up to 14 years) and adult (greater than 14 years). Frequency tables were used for descriptive statistics. Line graphs were plotted to explore the trends of referrals for each group, on the whole and across venues of referral.

3. Results

During the study period a total of 11,245 uro-radiological examinations were performed using either IVU (43.7%, $n = 4915$) or CTKUB (56.3%, $n = 6330$). A remarkable majority of procedures (95.5%, $n = 10741$) were performed in adult patients as compared to children (4.5%, $n = 504$).

Of those undergoing CTKUB, 68% ($n = 4290$) were males and 32% ($n = 2040$) were females whereas the respective proportions were 63% ($n = 3097$) and 37% ($n = 1818$) in case of IVU. Mean age of the patients who had a CTKUB performed was 39.8 ± 14.8 years, compared to 36.3 ± 16.5 years for those who had an IVU ($p < 0.001$, two-tailed t -test). Overall, the respective proportions of IVU and CTKUB were 87.9% ($n = 43$) and 12.1% ($n = 61$) in pediatric group whereas 41.6% ($n = 4472$) and 58.4% ($n = 6269$) in the adults.

The year-wise distribution (Fig. 1) indicates that the respective numbers of CTKUB and IVP were 423 (26%) and 1263 (74%) in year 2002; 627 (38%) and 1025 (62%) in year 2003; 1023 (53%) and 892 (47%) in year 2004; 1217 (63%) and 699 (37%) in year 2005; 1469 (72%) and 580 (28%) in year 2006 while 1571 (77%) and 456 (23%) in year 2007.

Based on referral location the majority of both examinations were referred from clinics as AP comprising 77% cases ($n = 8658$) followed by ED which is 12.7% ($n = 1428$) and least numbers ordered from HP 10.3% ($n = 1159$).

Referring specialty-wise, most of the cases were referred from urology clinic during the study period with total number of 5788 (51.5%). The second largest group comprised those referrals where the referring physician could not be identified, and were therefore excluded from further analysis of trend by specialty. It comprises 2954 (26.3) patients followed by referrals from medicine and allied department 1937 (17.2%) and 566 (5%) patients were sent by surgery and allied group.

In the pediatric population, very limited numbers of CTKUB were undertaken ranging from 3 to 20 scans per year with a mean of 10 scans, and shows an approximately 20% increase in referrals in the year 2007 as compared to year 2002 and on the other hand IVU which is a highly recommended modality in this age group shows

an almost 25% decrease in referrals in the respective years. This trend was from hospital affiliated clinics. The number of IVU ordered from ED was nil however CTKUB remains the referring modality of choice from ED. Decreasing IVU referrals seen from AP (outside referrals) and HP in which there is significant decline in referrals seen since 2006 with an almost 40% decrease noted while CTKUB shows an approximately 40% increase in the same period. Significant and steep decline in IVU referrals were seen from medicine and allied group where there is an approximately 70% decrease noted since mid-2004. This is followed by urology where an almost 50% decline of IVU referrals were seen from 2002 onwards. From both referral locations CTKUB is on the rise with significant change of referral trends noted from medicine and allied group with an approximately 75–80% rise in the year 2007. However IVU remains the modality of choice for surgery and allied group with no significant change in referral pattern throughout this period and very minimal number of CTKUB were referred from this location and these do not show any rise.

In the adult group, however, there is significant change seen during the study period with a significant rise in CTKUB and decline in IVU referrals in all almost all referring locations and specialties. The number of IVU ordered from ED was almost nil with maximum number ($n = 2$) referred in 2003 and is comparable to pediatric age group, on the other hand CTKUB was again the modality of choice in adults from ED. The significant difference between the adult and pediatric age group comes in respect to referral locations where in comparison there is significant decline in IVU and rise in CTKUB seen in AP (hospital affiliated clinics) and HP where major decline seen in 2004 and mid-2002, respectively with continuous fall and rise in these modalities. However in one of the subgroup of AP (i.e. outside referrals) there was a significant initial change noted starting from 2002 until 2004 from there onwards there is a plateau noted in the referrals of both modalities share almost 50% referrals till the year 2007. From specialty-wise significant rise in CTKUB referrals noted in all groups with maximum change in medicine and allied group.

The year-wise distribution for each age group with regard to gender and referral setting are given in Table 1. The comparative trends of CTKUB and IVU referrals are illustrated in Fig. 1(a–c).

4. Discussion

This six-year comparison of referral trends for acute flank pain revealed a remarkable shift from IVU to CTKUB for the adult patients. But IVU still comprises about a quarter of yearly exams in adult ambulatory patients. In addition, IVU has maintained its position as the preferred diagnostic choice in the pediatric age group.

Acute flank pain is a common and often confusing clinical problem which might be caused by a variety of urinary and extra urinary abnormalities with ureterolithiasis being the most frequent cause. Until recently, Plain abdominal radiographs combined with ultrasound and IVU have been the standard imaging procedures for the evaluation of acute flank pain. The utility of IVU may be potentially hampered by poor quality due to lack of bowel preparation, by nephrotoxicity of contrast agents, by serious allergic and anaphylactic reactions and by significant radiation exposure.

Whitfield and Whitfield⁶ recommend that the diagnostic imaging in urology should be accurate, safe, economical, available, adaptable and easy to interpret. Over the last 80 years, IVU has played a major role in the work-up of the upper urinary diseases. In a comparison of the cost and accuracy of multidetector computed tomography (MDCT) and intravenous urography (IVU), to establish the most cost-effective initial investigation for acute renal colic, Eikefjord et al.⁷ calculated that when expenses of equipment,

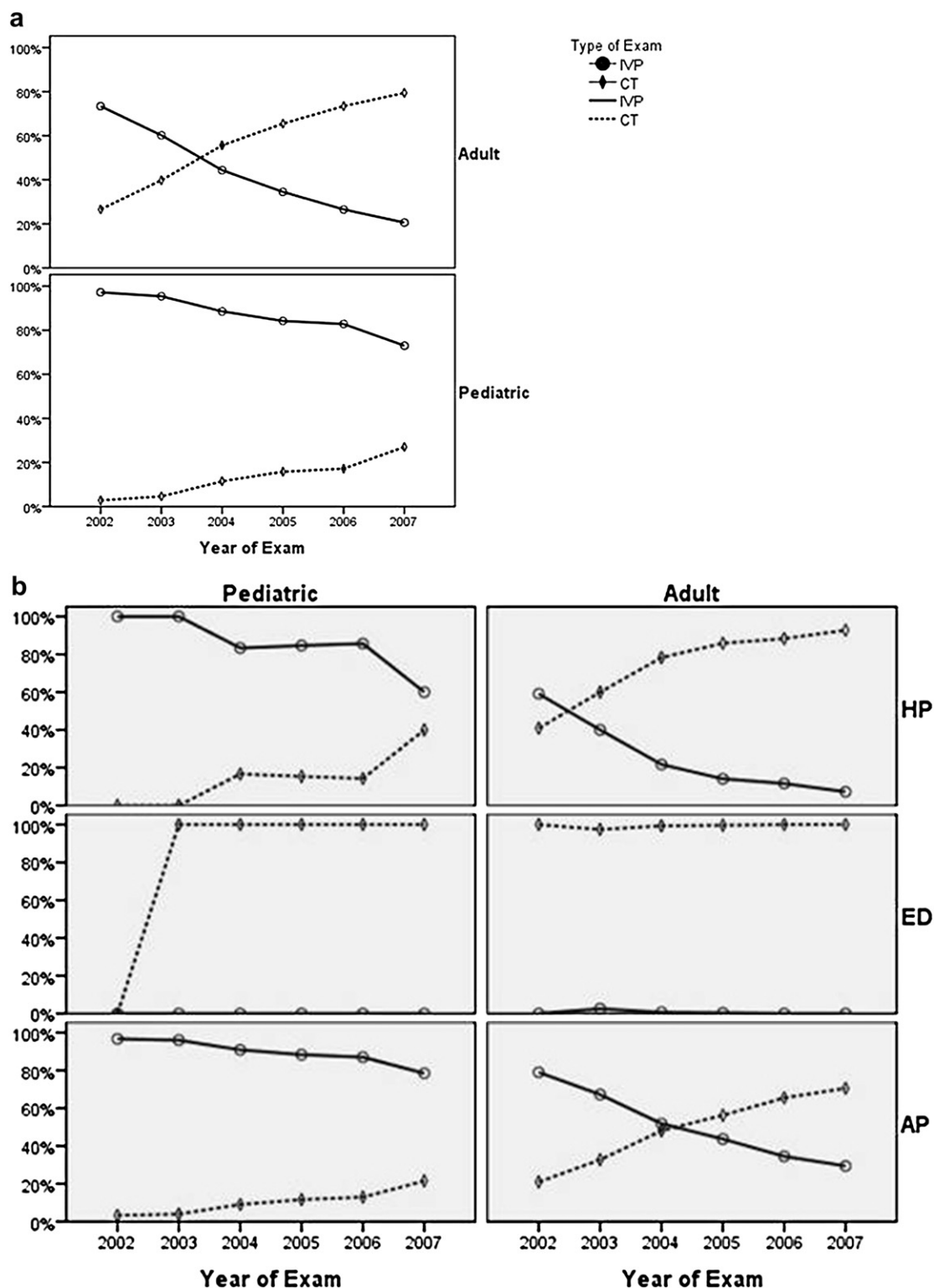


Fig. 1. Comparative trends of CT and IVU referrals in the study groups (pediatric and adult) from 2002 to 2007. (a) Overall (b) across referral settings (c) across gender.

consumables and human resource were taken into consideration, non-contrast MDCT was more cost-effective, better able to detect calculi and more capable of suggesting alternate diagnoses, in comparison to IVU. Another prospective comparison between IVU and CT also supported the latter owing to its superior diagnostic ability, safety profile, economy and time-efficiency.⁸ Besides the

radiation issue one other disadvantage of CT is the cost factor. CT in our institution cost £50 compared to IVU which costs ~£20. However, detailed cost-effectiveness should include use of further imaging following IVU like ultrasound, CT, etc. Longer stay in the emergency room, identification of other abdominal conditions, etc.

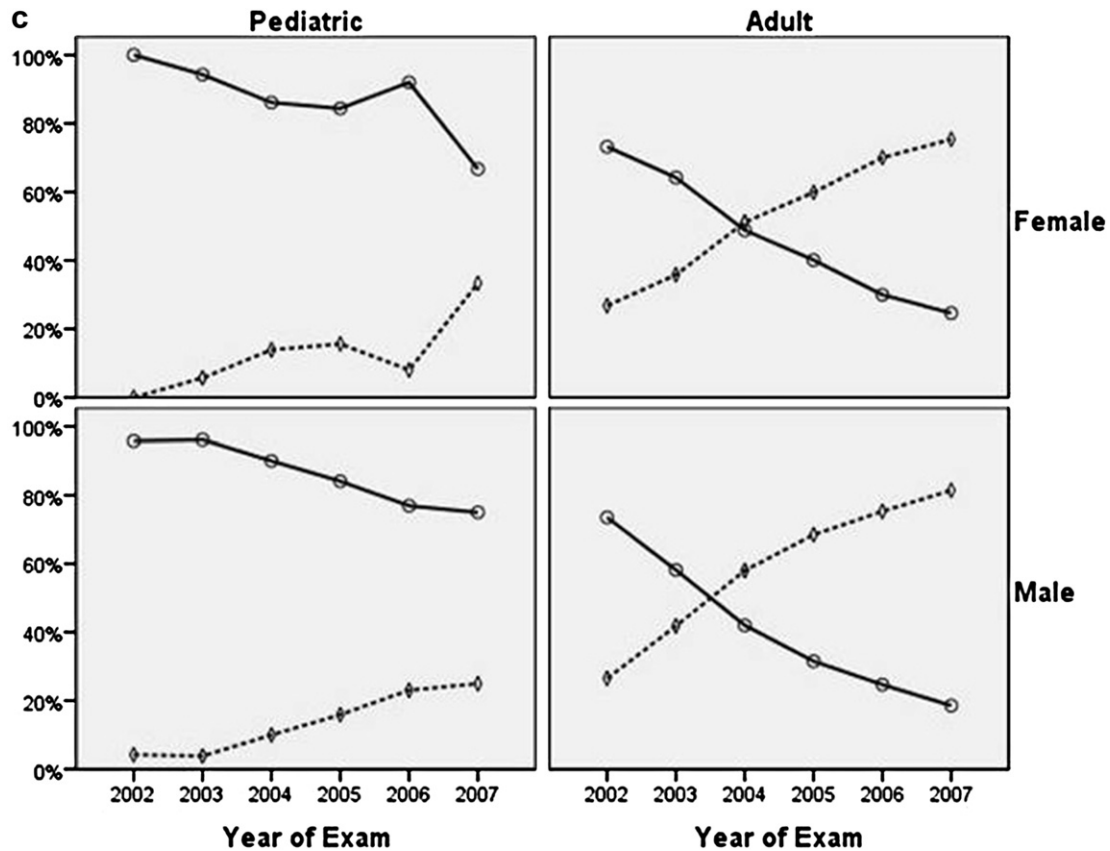


Fig. 1. (continued).

Grisi et al.⁹ set to analyze the costs of different diagnostic approaches in patients with acute flank pain. They compared the use of CTKUB alone, IVU alone and combinations of either with plain film and ultrasonography (US). They recommended against the use of IVU, either alone or in combination, owing to its higher cost, worse diagnostic yield and an equivalent radiation dose when compared to CTKUB. They suggested that, in unsolved cases, a combination of plain film, US and CTKUB should be preferred. This approach increases the time to reach a diagnostic conclusion than utilizing immediate CT but affords lower cost and radiation dose.

Patients with renal colic are better examined by non-enhanced CT scanning, since it can detect more stones (60% versus 100%).

In another study, Freed et al.¹⁰ reported very good agreement among attending radiologists and radiology resident for the evaluation of ureteral stone disease by CTKUB; the agreement between radiologists and urologist was found to be moderate in the same study. They concluded that, despite some limitations, CT is an accurate tool for the assessment of ureteral stone disease. Multi-detector CT (MDCT) may also contribute to the clinical decision more than any other modality. CT Hounsfield unit (HU) gives useful

Table 1

Year-wise distribution of the study groups (Pediatric and Adult) with respect to gender and referral setting.

	Gender		Referral setting			Total, n (%)
	Male, n	Female, n	AP, n	ED, n	HP, n	
Pediatric						
Year 2002	71	36	91	0	16	107 (21.2%)
Year 2003	52	35	75	1	11	87 (17.3%)
Year 2004	60	36	77	1	18	96 (19.0%)
Year 2005	44	32	60	3	13	76 (15.1%)
Year 2006	39	25	54	3	7	64 (12.7%)
Year 2007	56	18	65	4	5	74 (14.7%)
Overall	322 (63.9%)	182 (36.1%)	422 (83.7%)	12 (2.4%)	70 (13.9%)	504 (100%)
Adult						
Year 2002	1057	522	1282	50	247	1579 (14.7%)
Year 2003	1040	525	1267	78	220	1565 (14.6%)
Year 2004	1186	633	1475	155	189	1819 (16.9%)
Year 2005	1199	641	1398	279	163	1840 (17.1%)
Year 2006	1284	701	1478	361	146	1985 (18.5%)
Year 2007	1299	654	1336	493	124	1953 (18.2%)
Overall	7065 (65.8%)	3676 (34.2%)	8236 (76.7%)	1416 (13.2%)	1089 (10.1%)	10741 (100%)

AP, ambulatory patients; ED, emergency department patients; HP, hospitalized patients.

information in this regard; the outcome of lithotripsy appears more promising for stones with HU 550 or less whereas HU greater than 550 cautions the potential for more sessions of lithotripsy and a longer hospital stay. In addition, CT aids in detection of disease outside the upper urinary tract which is present in an estimated 12% of patients with renal colic.^{11,12} These alternate/ incidental diagnoses alter patient management and allow rapid triage in emergency departments.^{12–14} The extra-genitourinary findings may also have a long term clinical impact, e.g. in cases where malignancies are detected at an early, potentially curable stage.

Some of the indications for an IVU that currently remain are assessment of hematuria, detection of a urothelial tumour, assessment of certain congenital malformations and gross assessment of renal function in multi-trauma patient to evaluate functioning of the contra lateral kidney prior to laparotomy. IVU also finds application in diagnosing papillary necrosis and small calyceal diverticuli. This is particularly of value prior to endourological and percutaneous interventions. The detailed information about the size and location of stone(s), shape and angle of calyces, infundibular patency, dependant position of calyx, etc. has a bearing on outcome.

While CTKUB has achieved wide acceptability for evaluation of suspected urinary calculi in adults, the experience in pediatric population remains limited. Although head-to-head comparisons between IVU and CT are lacking, we can see accumulating evidence in favor of utility of CT for detection of urinary calculi and their associated signs in children.^{15–17} There is a need for optimization of CT imaging parameters, to attain a balance between diagnostic yield and radiation exposure.^{18,19} Kim and colleagues¹⁸ in their prospective comparison of standard-dose and low-dose CT (tube current 260 mAs and 50 mAs, respectively) concluded that about 81% decrease in the radiation dose could be achieved without compromising the diagnostic yield for ureteral stones and abnormalities unrelated to calculus disease. However, the low-dose protocol had limited capacity for detection of calculi with diameter less than or equal to 2 mm. Poletti et al.²⁰ also reported similar findings for a comparison between 180 mAs and 30 mAs CT protocols. These advantages of remarkable stone detection rates and alternate diagnoses have been reported even for radically low-dose protocols (approx. 7 mAs); a dose equivalent to plain X-ray KUB.²¹

Proponents of IVU for the assessment of renal colic, rest their case on two points; a lower cost and the provision of functional data. However, the former point does not hold true in comparison to plain CT whereas the presence of specific CT signs of increased pressure stands against the latter. CT clearly holds the superior ground for evaluation of flank pain owing to its near-perfect diagnostic yield for detection of urinary calculi, potential for suggesting alternate diagnoses, time-efficiency and the exclusion of iodinated contrast related risks.

In the pediatric group, IVU has remained the preferred modality throughout the study period. However, the trends appear to be trailing, with a guarded pace, those seen in adults. A number of reasons may be contemplated for this incongruity. Firstly, pathologies more likely in pediatric age group are distinct from those probable in adults and may be better delineated with a functional study such as IVU.⁴ Secondly, experience with CTKUB in pediatric population is limited. The evidence, though in favor of CT, has just started to accumulate^{17–19} and prospective comparisons with IVU are still lacking. Thirdly, radiation exposure is a greater concern in children² and parameters balancing diagnostic yield and radiation dose of pediatric CTKUB are yet to be established.^{18,19} Since studies in pediatric population require extreme meticulousness, it would be safe to assume that this trend would continue for quite some time.

5. Conclusion

Acute ureteric colic is a common surgical emergency. There is a shift towards using non-contrast CT for evaluating ureteric colic. Multiple inherent advantages of CT are the primary reasons for it becoming the modality of choice. CT is fast replacing an old and trusted friend who has served us faithfully for over 80 years.

Conflict of interest statement

No conflicts of interest.

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Ethical approval

Exempted from ERC approval.

References

- Miller OF, Rineer SK, Reichard SR, et al. Prospective comparison of unenhanced spiral computed tomography and intravenous urogram in the evaluation of acute flank pain. *Urology* 1998;**52**:982–7.
- Reddy S. State of the art trends in imaging renal of colic. *Emerg Radiol* 2008 Jul;**15**(4):217–25.
- Masarani M, Dinneen M. Ureteric colic: new trends in diagnosis and treatment. *Postgrad Med J* 2007 Jul;**83**(981):469–72.
- Leusmann DB, Niggemann H, Roth S, von Ahlen H. Recurrence rates and severity of urinary calculi. *Scand J Urol Nephrol* 1995;**29**:279–83.
- Chowdhury FU, Kotwal S, Raghunathan G, Wah TM, Joyce A, Irving HC. Unenhanced multidetector CT (CT KUB) in the initial imaging of suspected acute renal colic: evaluating a new service. *Clin Radiol* 2007 Oct;**62**(10):970–7.
- Whitfield A, Whitfield HN. Is there a role for the intravenous urogram in the 21st century? *Ann R Coll Surg Engl* 2006 January;**88**(1):62–5.
- Eikefjord E, Askildsen JE, Rørvik J. Cost-effectiveness analysis (CEA) of intravenous urography (IVU) and unenhanced multidetector computed tomography (MDCT) for initial investigation of suspected acute ureterolithiasis. *Acta Radiol* 2008 Mar;**49**(2):222–9.
- Pfister SA, Deckart A, Laschke S, Dellas S, Otto U, Buitrago C, et al. Unenhanced helical computed tomography vs intravenous urography in patients with acute flank pain: accuracy and economic impact in a randomized prospective trial. *Eur Radiol* 2003 Nov;**13**(11):2513–20. Epub 2003 Jul 24.
- Grisi G, Stacul F, Cuttin R, Rimondini A, Meduri S, Dalla Palma L. Cost analysis of different protocols for imaging a patient with acute flank pain. *Eur Radiol* 2000;**10**(10):1620–7.
- Freed KS, Paulson EK, Frederick MG, Preminger GM, Shusterman DJ, Keogan MT, et al. Interobserver variability in the interpretation of unenhanced helical CT for the diagnosis of ureteral stone disease. *J Comput Assist Tomogr* 1998 Sep–Oct;**22**(5):732–7.
- Wang JH, Shen SH, Huang SS, Chang CY. Prospective comparison of unenhanced spiral computed tomography and intravenous urography in the evaluation of acute renal colic. *J Chin Med Assoc* 2008;**71**:30–6.
- Ahmad NA, Ather MH, Rees J. Incidental diagnosis of diseases on un-enhanced helical computed tomography performed for ureteric colic. *BMC Urol* 2003 Mar 17;**3**:2.
- Hoppe H, Studer R, Kessler TM, Vock P, Studer UE, Thoeny HC. Alternate or additional findings to stone disease on unenhanced computerized tomography for acute flank pain can impact management. *J Urol* 2006 May;**175**(5):1725–30.
- Ather MH, Faizullah K, Achakzai I, Irani F, Siwani R. The diagnostic ability of non-contrast enhanced CT for acute flank pain- urolithiasis and beyond. *Urology Journal* 2009;**6**(1):14–8.
- Strouse PJ, Bates DG, Bloom DA, Goodsitt MM. Non-contrast thin-section helical CT of urinary tract calculi in children. *Pediatr Radiol* 2002 May;**32**(5):326–32.
- Palmer JS, Donaher ER, O'Riordan MA, Dell KM. Diagnosis of pediatric urolithiasis: role of ultrasound and computerized tomography. *J Urol* 2005 Oct;**174**(4 Pt 1):1413–6.
- Akay H, Akpinar E, Ergun O, Ozmen CA, Haliloglu M. Unenhanced multidetector CT evaluation of urinary stones and secondary signs in pediatric patients. *Diagn Interv Radiol* 2006 Sep;**12**(3):147–50.
- Kim BS, Hwang IK, Choi YW, Namkung S, Kim HC, Hwang WC, et al. Low-dose and standard-dose unenhanced helical computed tomography for the assessment of acute renal colic: prospective comparative study. *Acta Radiol* 2005 Nov;**46**(7):756–63.
- Ather MH, Memon WA. Stones: impact of dose reduction on CT detection of urolithiasis. *Nat Rev Urol* 2009 Oct;**6**(10):526–7.
- Poletti PA, Platon A, Rutschmann OT, Schmidlin FR, Iselin CE, Becker CD. Low-dose versus standard-dose CT protocol in patients with clinically suspected renal colic. *AJR Am J Roentgenol* 2007 Apr;**188**(4):927–33.
- Kluner C, Hein PA, Gralla O, Hein E, Hamm B, Romano V, et al. Does ultra-low-dose CT with a radiation dose equivalent to that of KUB suffice to detect renal and ureteral calculi? *J Comput Assist Tomogr* 2006 Jan–Feb;**30**(1):44–50.